MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 1, 2019/2020

EEL2186–CIRCUITS AND SIGNALS
(All Sections/Groups)

16 OCTOBER 2019
9.00 A.M –11.00 A.M.
(2 Hours)

INSTRUCTIONS TO STUDENT

1. This question paper consists of 9 pages including cover page with 5 questions only.
2. Attempt **ALL FIVE** questions. The distribution of the marks for each question is given.
3. Please write all your answers in the answer booklet provided.
4. The Laplace Transform Pairs, Laplace Transform Properties and Two-port Network Conversion tables are as given in Appendices A, B and C respectively for your reference.

Question 1

(a) Consider the network graph shown in **Figure Q1(a)(i)** and one of its trees in **Figure Q1(a)(ii)**.

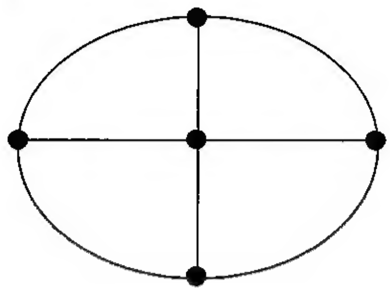

Figure Q1(a)(i)

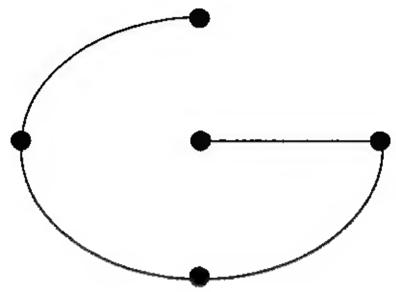

Figure Q1(a)(ii)

(i) Draw two other trees for the network graph of **Figure Q1(a)(i)**. [2 marks]

(ii) Redraw **Figure Q1(a)(ii)**, showing clearly all the links and fundamental cutsets. [4 marks]

(b) A network is given with its corresponding graph as shown in **Figure Q1(b)**.

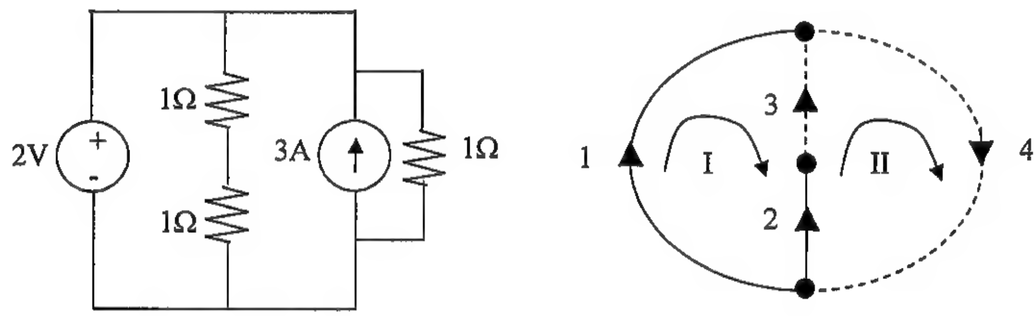

Figure Q1(b)

(i) Obtain the voltage source matrix E, current source matrix I, branch impedance matrix Z and mesh incidence matrix B. [4 marks]

(ii) Use mesh analysis to solve for the mesh currents. (You need not solve for the branch currents and voltages.) [6 marks]

Continued...

Question 2

(a) A signal is given as: $f(t) = 3\{u(t) - u(t-2)\}$.

(i) Sketch the signal $f(t)$. [3 marks]

(ii) $f(t)$ can also be expressed using a pulse function:

$$f(t) = aP_b(t-c)$$

Based on the sketched $f(t)$ signal in part (a)(i), determine the values of a, b and c respectively. [3 marks]

(b) A discrete signal is as follows:

$$x[n] = \{\ldots 0\ 1\ 2\ 5\ 0 \ldots\}$$

(i) Write the expression to synthesise $x[n]$ using only step functions and only delta functions, respectively. (Note: Write 2 expressions separately, one using step functions only and another using delta functions only). [4 marks]

(ii) Let $y[n] = x[n] * h[n]$. Find $y[n]$ if $h[n] = \{\ldots 0\ 1\ 3\ 5\ 0 \ldots\}$. [7 marks]

Continued...

Question 3

Consider the circuit shown in **Figure Q3** where Network A is a *T*-network and Network B is a π-network.

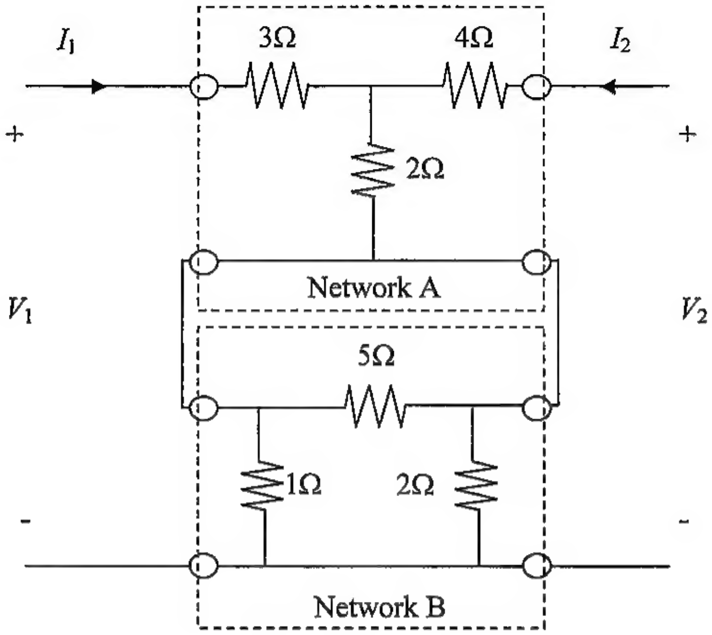

Figure Q3

(a) Determine the z-parameters of Network A. [5 marks]
(b) Determine the y-parameters of Network B. [5 marks]
(c) Using your answers in parts (a) and (b), determine the z-parameters of the overall network. [7 marks]

Continued...

Question 4

(a) The differential equation given represents a linear time-invariant (LTI) electrical system.

$$\frac{dy^2(t)}{dt^2} + 7\frac{dy(t)}{dt} + 10y(t) = 4x(t)$$

(i) Find the output, $y(t)$ for input $x(t) = u(t)$. Assume zero initial conditions. [8 marks]

(ii) Based on the expression obtained for $y(t)$ in part (a)(i), determine the final value of $y(t), y(\infty)$. [2 marks]

(b) For the circuit shown in **Figure Q4(b)**, identify the state variables. Hence, derive the state equations. Assume $V_{in}(t)$ as the input. [15 marks]

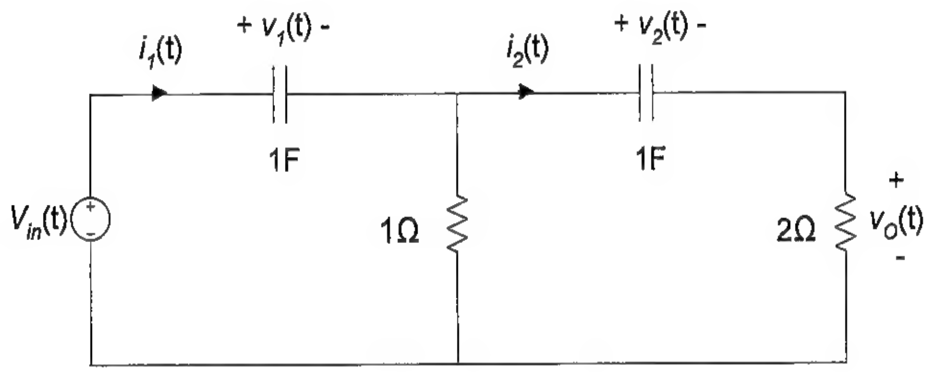

Figure Q4(b)

Continued...

Question 5

(a) Can the following function be realised as a resistor-capacitor (RC) network? Justify your answer.

$$Z(s) = \frac{s^2+6s+8}{s^2+4s+3}$$

[5 marks]

(b) Synthesise $Z(s) = \frac{s^4+3s^2+1}{s(s^2+1)}$ as an inductor-capacitor (LC) network using Cauer 1st form.

[8 marks]

(c) State three differences between an ideal lowpass filter and a real (practical) lowpass filter. [6 marks]

(d) Given that a fourth order Butterworth filter has 3dB passband edge located at 5kHz, determine its attenuation at 7kHz. [6 marks]

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Appendix A: Table of Laplace Transform Pairs

No.	*t*-domain function	*s*-domain transform
1.	$\delta(t)$	1
2.	$u(t)$	$1/s$
3.	$tu(t)$	$1/s^2$
4.	t^n	$\frac{n!}{s^{n+1}}$
5.	e^{-kt}	$\frac{1}{s+k}$
6.	$t^n e^{-kt}$	$\frac{n!}{(s+k)^{n+1}}$
7.	$sin\omega t$	$\frac{\omega}{s^2+\omega^2}$
8.	$cos\omega t$	$\frac{s}{s^2+\omega^2}$
9.	$e^{-kt}sin\omega t$	$\frac{\omega}{(s+k)^2+\omega^2}$
10.	$e^{-kt}cos\omega t$	$\frac{s+k}{(s+k)^2+\omega^2}$
11.	$tsin\omega t$	$\frac{2\omega s}{(s^2+\omega^2)^2}$
12.	$sinh\beta t$	$\frac{\beta}{s^2-\beta^2}$
13.	$cosh\beta t$	$\frac{s}{s^2-\beta^2}$
14.	$sin(\omega t+\phi)$	$\frac{s\sin\phi+\omega\cos\phi}{s^2+\omega^2}$
15.	$2\lvert k\rvert e^{-\sigma t}\cos(\omega t-\varphi)$, where $k=\lvert k\rvert\angle\varphi$	$\frac{k}{s+\sigma+j\omega}+\frac{k^*}{s+\sigma-j\omega}$
16.	$f(t)$ periodic with period T	$\frac{1}{1-e^{-Ts}}\int_0^T f(t)e^{-st}dt$

Continued…

Appendix B: Table of Laplace Transform Properties

Operations	$f(t)$	$F(s)$
1. Multiplication by scalar	$kf(t)$	$kF(s)$
2. Scaling	$f(kt),\ k\geq 0$	$\frac{1}{k}F\left(\frac{s}{k}\right)$
3. Addition and subtraction	$f_1(t)\pm f_2(t)$	$F_1(s)\pm F_2(s)$
4. Time shift	$f(t-t_o)u(t-t_o)$	$F(s)e^{-st_o}$
5. Frequency shift	$f(t)e^{\alpha t}$	$F(s-\alpha)$
6. Time differentiation	$\frac{df(t)}{dt}$	$sF(s) - f(0)$
	$\frac{d^2f(t)}{dt^2}$	$s^2F(s) - sf(0) - f'(0)$
7. Time integration	$\int_0^t f(\tau)d\tau$	$\frac{1}{s}F(s)$
8. Initial value	$\lim_{t\to 0} f(t)$	$\lim_{s\to\infty} sF(s)$
9. Final value	$\lim_{t\to\infty} f(t)$	$\lim_{s\to 0} sF(s)$
10. Frequency differentiation	$tf(t)$	$-\frac{dF(s)}{ds}$
11. Frequency integration	$\frac{f(t)}{t}$	$\int_s^\infty F(\tilde{s})d\tilde{s}$
12. Convolution	$f_1(t)*f_2(t)$	$F_1(s)F_2(s)$

Continued…

Appendix C: Two-port network conversion table between *z*-, *y*-, *h*-, *g*-, *a*- and *b*-parameters.

	z	y	h	g	a	b
z	$\begin{matrix} z_{11} & z_{12} \\ z_{21} & z_{22} \end{matrix}$	$\begin{matrix} \frac{y_{22}}{\Delta y} & -\frac{y_{12}}{\Delta y} \\ -\frac{y_{21}}{\Delta y} & \frac{y_{11}}{\Delta y} \end{matrix}$	$\begin{matrix} \frac{\Delta h}{h_{22}} & \frac{h_{12}}{h_{22}} \\ -\frac{h_{21}}{h_{22}} & \frac{1}{h_{22}} \end{matrix}$	$\begin{matrix} \frac{1}{g_{11}} & -\frac{g_{12}}{g_{11}} \\ \frac{g_{21}}{g_{11}} & \frac{\Delta g}{g_{11}} \end{matrix}$	$\begin{matrix} \frac{A}{C} & \frac{\Delta a}{C} \\ \frac{1}{C} & \frac{D}{C} \end{matrix}$	$\begin{matrix} \frac{d}{c} & \frac{1}{c} \\ \frac{\Delta b}{c} & \frac{a}{c} \end{matrix}$
y	$\begin{matrix} \frac{z_{22}}{\Delta z} & -\frac{z_{12}}{\Delta z} \\ -\frac{z_{21}}{\Delta z} & \frac{z_{11}}{\Delta z} \end{matrix}$	$\begin{matrix} y_{11} & y_{12} \\ y_{21} & y_{22} \end{matrix}$	$\begin{matrix} \frac{1}{h_{11}} & -\frac{h_{12}}{h_{11}} \\ \frac{h_{21}}{h_{11}} & \frac{\Delta h}{h_{11}} \end{matrix}$	$\begin{matrix} \frac{\Delta g}{g_{22}} & \frac{g_{12}}{g_{22}} \\ -\frac{g_{21}}{g_{22}} & \frac{1}{g_{22}} \end{matrix}$	$\begin{matrix} \frac{D}{B} & -\frac{\Delta a}{B} \\ -\frac{1}{B} & \frac{A}{B} \end{matrix}$	$\begin{matrix} \frac{a}{b} & -\frac{1}{b} \\ -\frac{\Delta b}{b} & \frac{d}{b} \end{matrix}$
h	$\begin{matrix} \frac{\Delta z}{z_{22}} & \frac{z_{12}}{z_{22}} \\ -\frac{z_{21}}{z_{22}} & \frac{1}{z_{22}} \end{matrix}$	$\begin{matrix} \frac{1}{y_{11}} & -\frac{y_{12}}{y_{11}} \\ \frac{y_{21}}{y_{11}} & \frac{\Delta y}{y_{11}} \end{matrix}$	$\begin{matrix} h_{11} & h_{12} \\ h_{21} & h_{22} \end{matrix}$	$\begin{matrix} \frac{g_{22}}{\Delta g} & -\frac{g_{12}}{\Delta g} \\ -\frac{g_{21}}{\Delta g} & \frac{g_{11}}{\Delta g} \end{matrix}$	$\begin{matrix} \frac{B}{D} & \frac{\Delta a}{D} \\ -\frac{1}{D} & \frac{C}{D} \end{matrix}$	$\begin{matrix} \frac{b}{a} & \frac{1}{a} \\ -\frac{\Delta b}{a} & \frac{c}{a} \end{matrix}$
g	$\begin{matrix} \frac{1}{z_{11}} & -\frac{z_{12}}{z_{11}} \\ \frac{z_{21}}{z_{11}} & \frac{\Delta z}{z_{11}} \end{matrix}$	$\begin{matrix} \frac{\Delta y}{y_{22}} & \frac{y_{12}}{y_{22}} \\ -\frac{y_{21}}{y_{22}} & \frac{1}{y_{22}} \end{matrix}$	$\begin{matrix} \frac{h_{22}}{\Delta h} & -\frac{h_{12}}{\Delta h} \\ -\frac{h_{21}}{\Delta h} & \frac{h_{11}}{\Delta h} \end{matrix}$	$\begin{matrix} g_{11} & g_{12} \\ g_{21} & g_{22} \end{matrix}$	$\begin{matrix} \frac{C}{A} & -\frac{\Delta a}{A} \\ \frac{1}{A} & \frac{B}{A} \end{matrix}$	$\begin{matrix} \frac{c}{d} & -\frac{1}{d} \\ \frac{\Delta b}{d} & \frac{b}{d} \end{matrix}$
a	$\begin{matrix} \frac{z_{11}}{z_{21}} & \frac{\Delta z}{z_{21}} \\ \frac{1}{z_{21}} & \frac{z_{22}}{z_{21}} \end{matrix}$	$\begin{matrix} -\frac{y_{22}}{y_{21}} & -\frac{1}{y_{21}} \\ -\frac{\Delta y}{y_{21}} & -\frac{y_{11}}{y_{21}} \end{matrix}$	$\begin{matrix} -\frac{\Delta h}{h_{21}} & -\frac{h_{11}}{h_{21}} \\ -\frac{h_{22}}{h_{21}} & -\frac{1}{h_{21}} \end{matrix}$	$\begin{matrix} \frac{1}{g_{21}} & \frac{g_{22}}{g_{21}} \\ \frac{g_{11}}{g_{21}} & \frac{\Delta g}{g_{21}} \end{matrix}$	$\begin{matrix} A & B \\ C & D \end{matrix}$	$\begin{matrix} \frac{d}{\Delta b} & \frac{b}{\Delta b} \\ \frac{c}{\Delta b} & \frac{a}{\Delta b} \end{matrix}$
b	$\begin{matrix} \frac{z_{22}}{z_{12}} & \frac{\Delta z}{z_{12}} \\ \frac{1}{z_{12}} & \frac{z_{11}}{z_{12}} \end{matrix}$	$\begin{matrix} -\frac{y_{11}}{y_{12}} & -\frac{1}{y_{12}} \\ -\frac{\Delta y}{y_{12}} & -\frac{y_{22}}{y_{12}} \end{matrix}$	$\begin{matrix} \frac{1}{h_{12}} & \frac{h_{11}}{h_{12}} \\ \frac{h_{22}}{h_{12}} & \frac{\Delta h}{h_{12}} \end{matrix}$	$\begin{matrix} -\frac{\Delta g}{g_{12}} & -\frac{g_{22}}{g_{12}} \\ -\frac{g_{11}}{g_{12}} & -\frac{1}{g_{12}} \end{matrix}$	$\begin{matrix} \frac{D}{\Delta a} & \frac{B}{\Delta a} \\ \frac{C}{\Delta a} & \frac{A}{\Delta a} \end{matrix}$	$\begin{matrix} a & b \\ c & d \end{matrix}$

$\Delta z = z_{11}z_{22} - z_{12}z_{21}$; $\Delta y = y_{11}y_{22} - y_{12}y_{21}$

$\Delta h = h_{11}h_{22} - h_{12}h_{21}$; $\Delta g = g_{11}g_{22} - g_{12}g_{21}$

$\Delta a = AD - BC$; $\Delta b = ad - bc$

End of Paper.